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AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

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Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

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MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO) 27 June 2002

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2002-166**
C.T. Liu (PRSM), "Investigating the Constraint Effect in a Particulate Composite Material" (viewgraphs)

ASME Pressure Vessel Technology Meeting **(Statement A)**
(Vancouver, Canada, 7-9 August 2002) (Deadline: 30 July 2002)

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PHILIP A. KESSEL Date
Technical Advisor
Space and Missile Propulsion Division

Investigating the Constraint Effect in a Particulate Composite Material

C. T. Liu
AFRL/PRSM
10 E. Saturn Blvd.
Edwards AFB CA U.S. A.
93524-7680,

Objectives

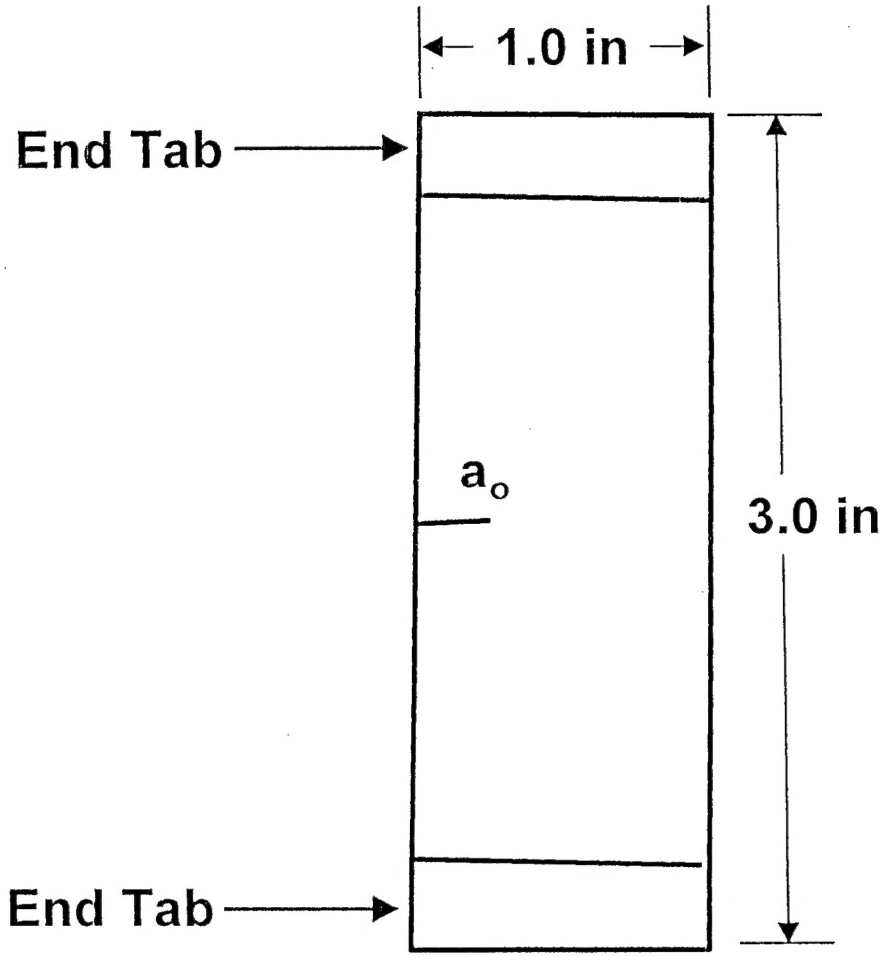
- Investigate the Constraint Effect on the Critical Stress Intensity Factor, K_{Ii}, for the Onset of Crack Growth in a Particulate Composite Material
  - Specimen Thickness: 0.2 in., 0.5 in., 1.0 in., 1.5 in.

- Initial Crack Length: 0.2 in., 0.3 in., 0.4 in.

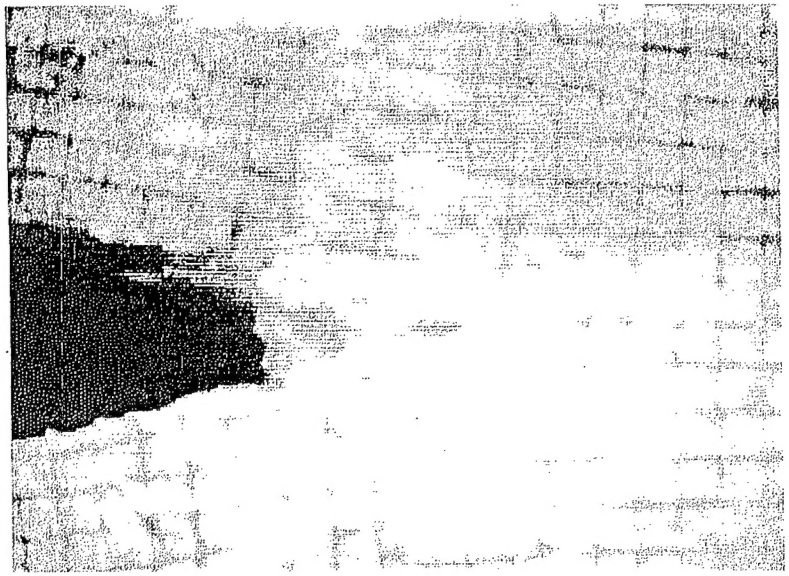
Conclusions

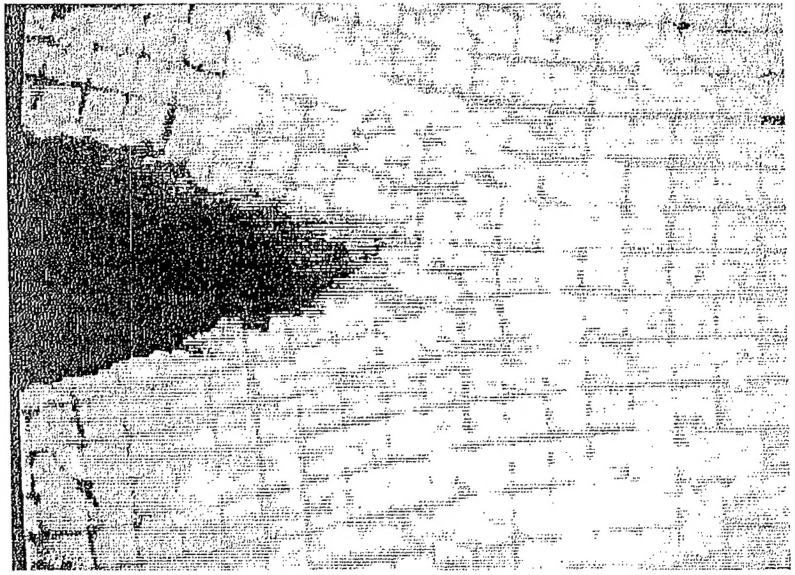
- Experimental findings indicate that, on the first approximation, K_{Ii} is independent of specimen thickness and initial crack length for the cases considered in this study.
- Due to the development of damage at the crack tip, the constraint is minimized at the crack tip and the Poisson's effect is negligible.
- For the particulate composite material under investigation, the plane-strain fracture toughness does not exist

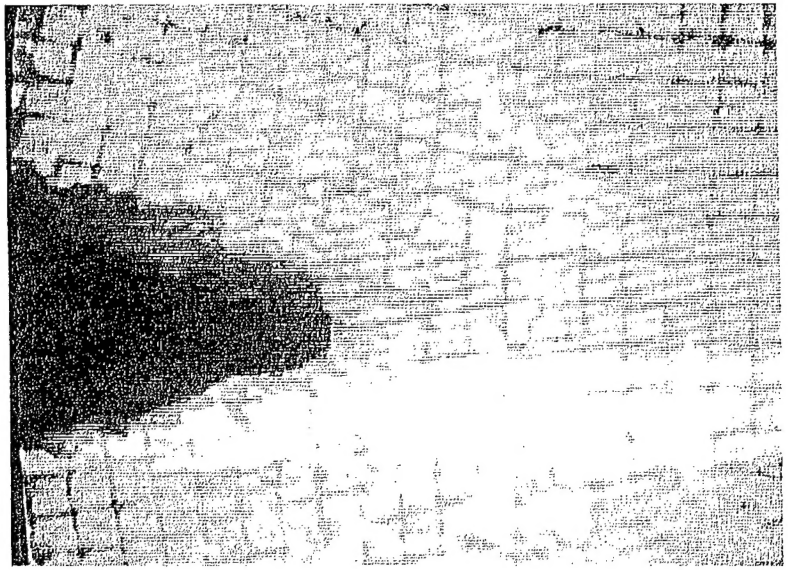
Specimen Geometry



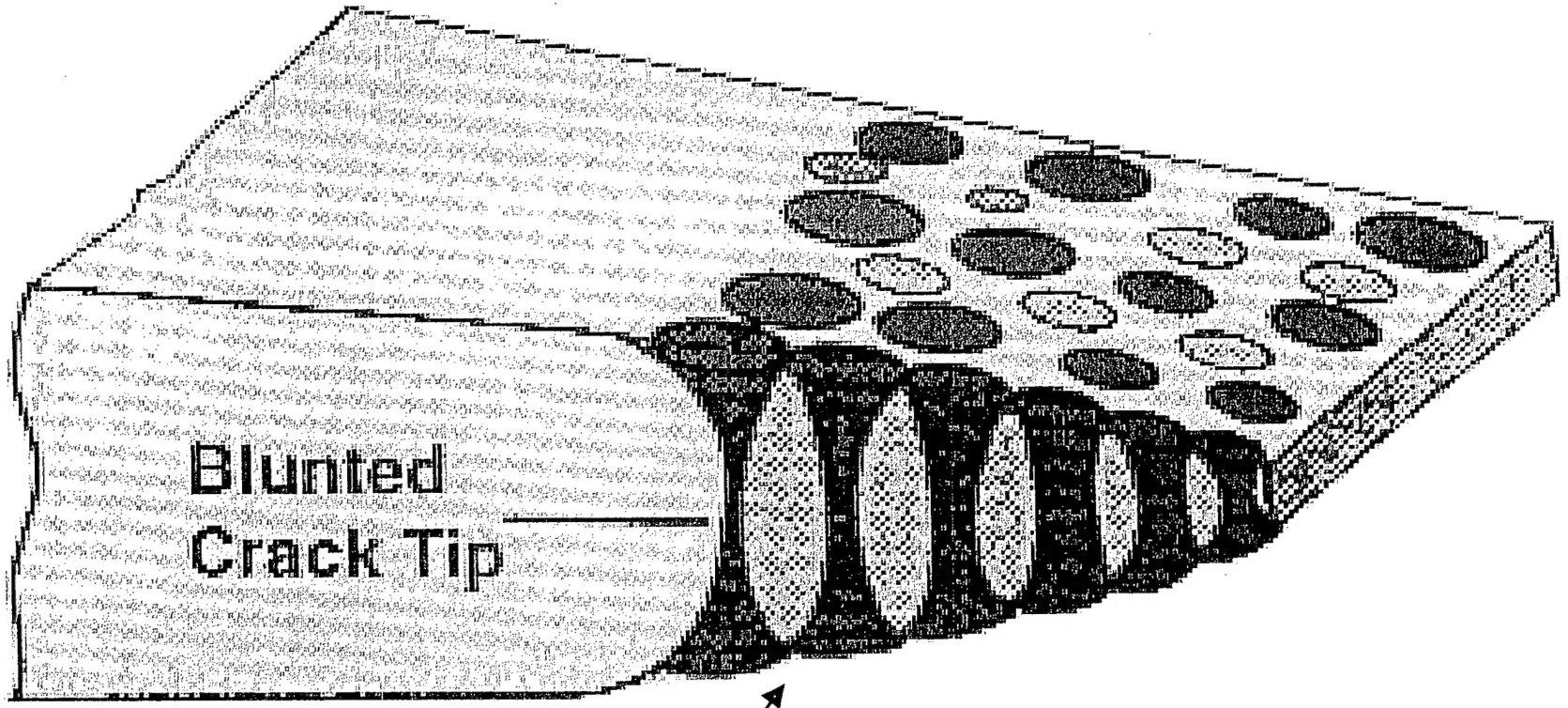
Crack Tip Profiles
(crosshead speed = 0.508 mm/min)





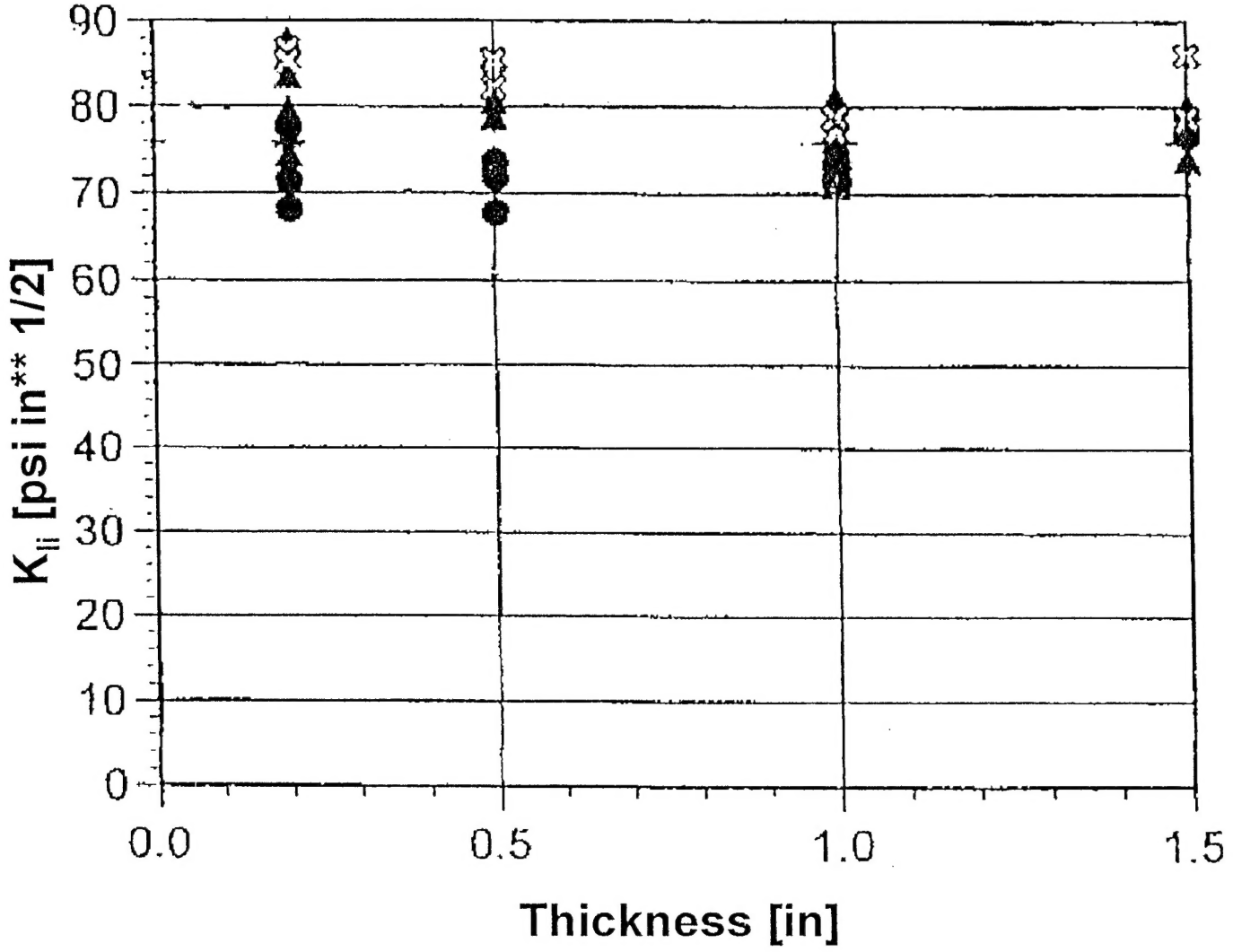


Crack Tip Damage Model

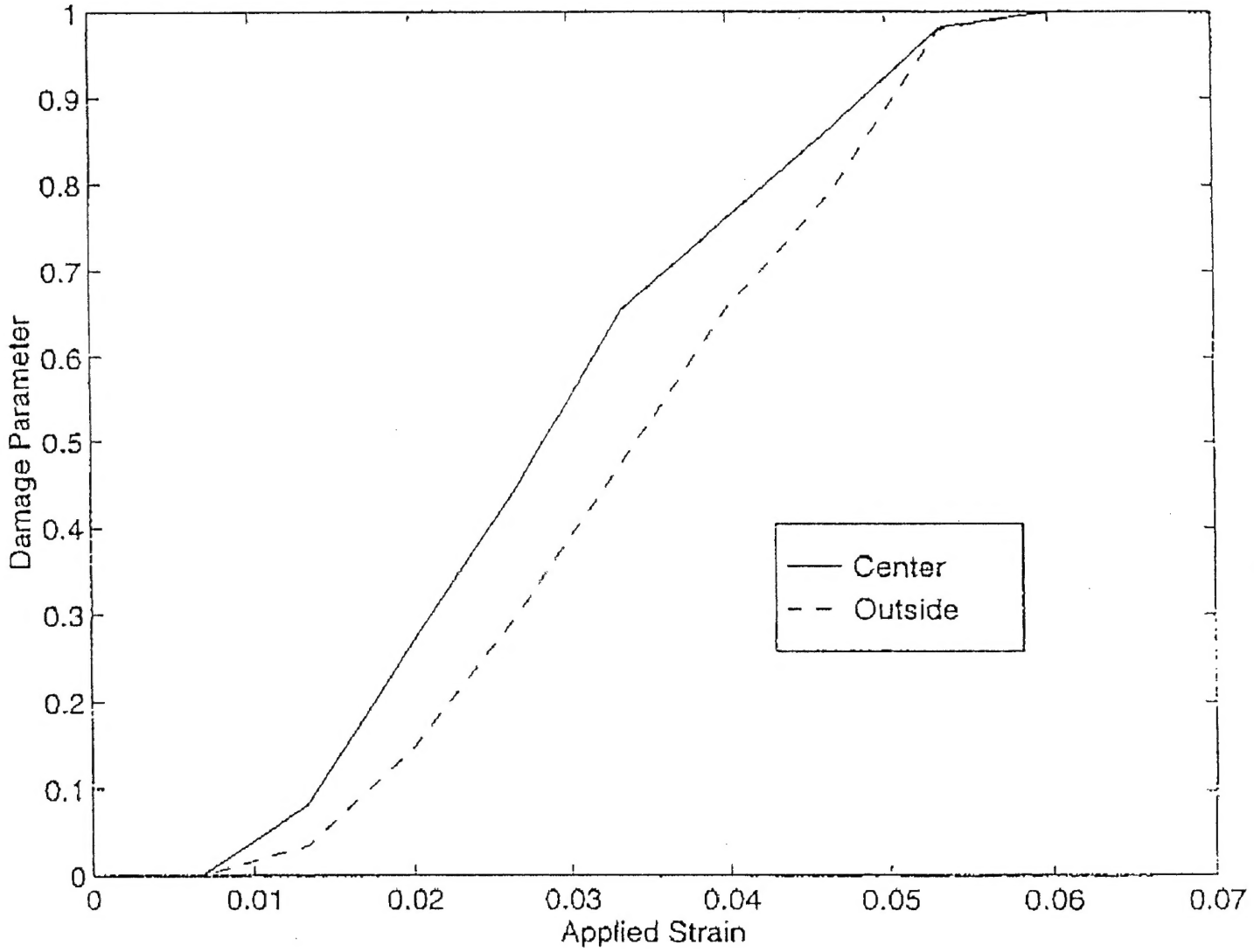


Highly Damaged Zone

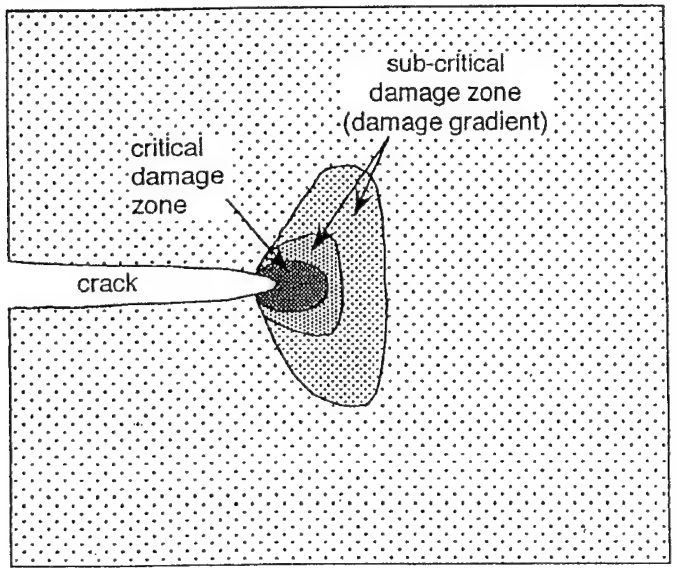
Mode I Stress Intensity Factor vs. Specimen Thickness. (Ambient Pressure)

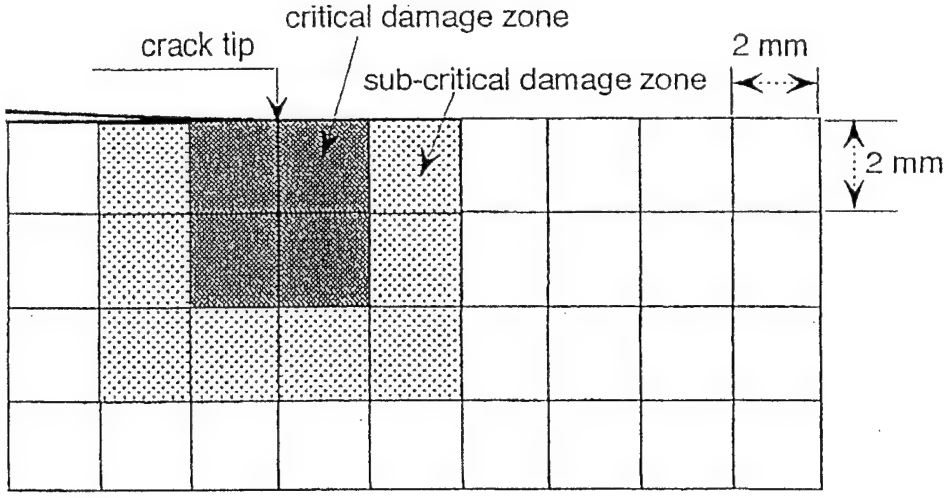


Damage Distribution near the Center and the Surface of the Specimen



Finite Element Model





FEM mesh at crack tip

Finite Element Models of the Three Layers of the Analyzed Specimen

inner layer

crack tip

2 mm

2 mm

381	353	325	297	269	241	213	182	151
378	350	322	294	266	238	210	183	152
375	347	319	291	263	235	207	179	156
371	343	315	287	259	231	203	176	148

middle layer

crack tip

382	354	326	298	270	242	214	185	154
379	351	323	295	267	239	211	184	153
376	348	320	292	264	236	208	180	157
372	344	316	288	260	232	204	177	149

outer layer

crack tip

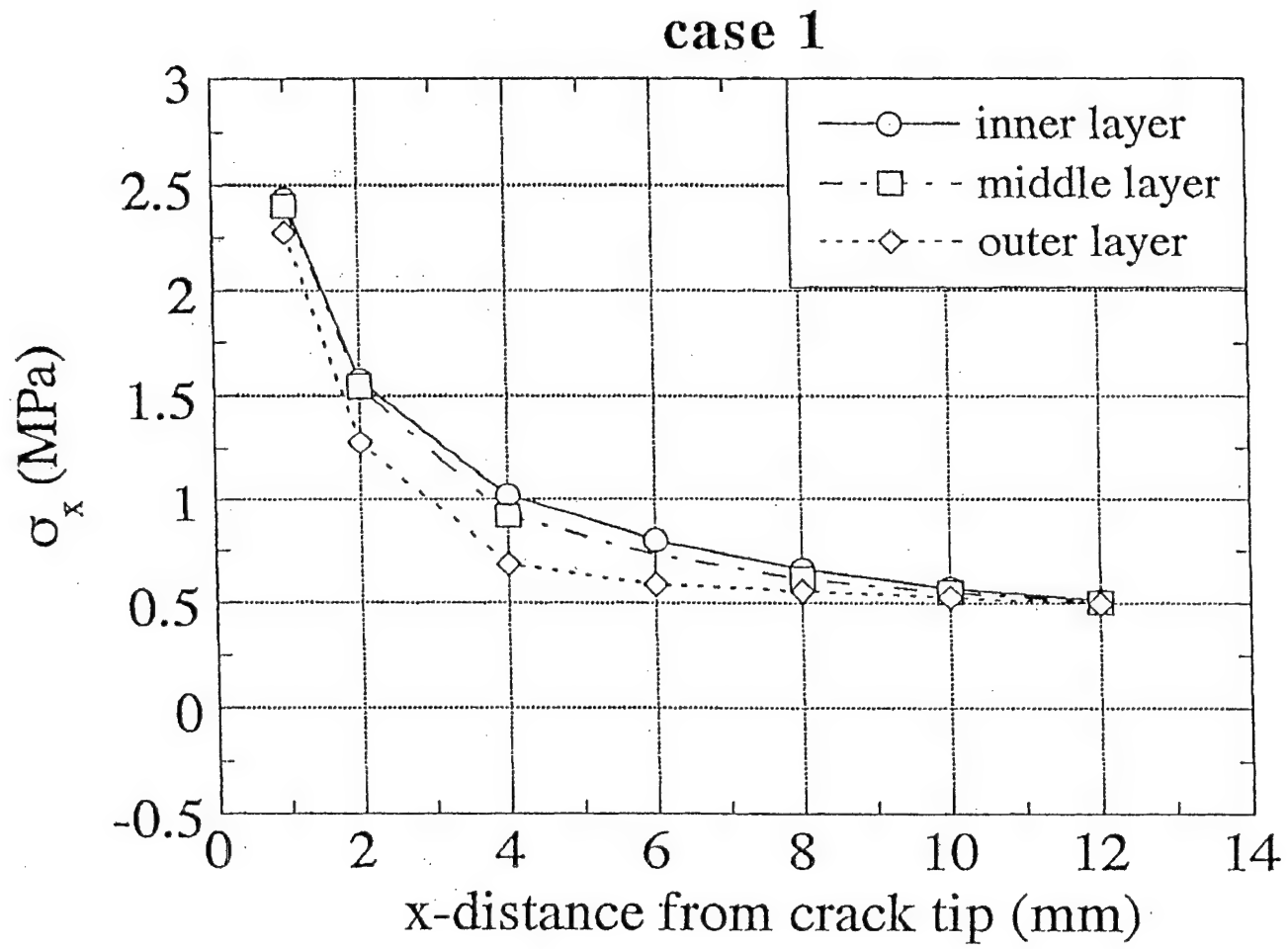
383	355	327	299	271	243	215	187	159
380	352	324	296	268	240	212	186	155
377	349	321	293	265	237	209	181	158
373	345	317	289	261	233	205	178	150

Summary of Crack-damage Interaction Analysis

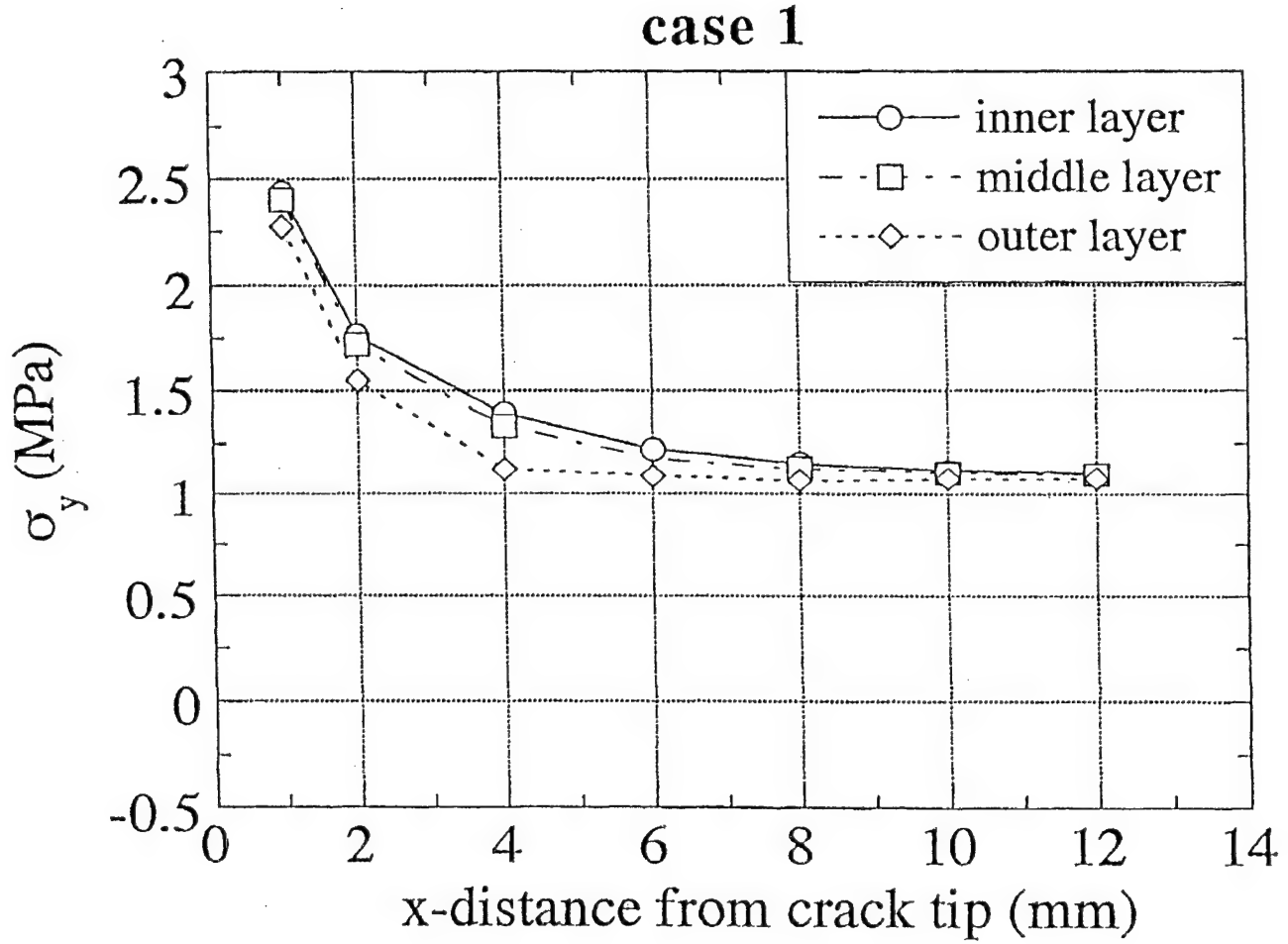
case	damage element	damage element modulus MPa (psi)	Poisson's ratio	inside layer K_I MPa-cm$^{0.5}$	middle layer K_I MPa-cm$^{0.5}$	outside layer K_I MPa-cm$^{0.5}$
thin*	none	0.414 (60)	0.4999	1.871	-	-
1	none	-	0.4999	1.931	1.903	1.802
2	325, 297	0.414 (60)	0.4999	0.422	2.246	1.871
3	325, 297 326, 298	0.414 (60)	0.4999	0.535	0.440	2.208
4	325, 297 326, 298 327, 299	0.414 (60)	0.4999	0.573	0.524	0.455
5	325, 297, 322, 294	0.414 (60)	0.4999	0.392	2.285	1.906
6	325, 297, 322, 294 326, 298, 323, 295 327, 299, 324, 296	0.414 (60)	0.4999	0.522	0.497	0.432
7	325, 297, 322, 294 326, 298, 323, 295 327, 299, 324, 296 353, 350 ,347, 319 291, 263, 266, 269 354, 351, 349, 320 292, 264, 267, 270 355, 352, 349, 321 293, 265, 268, 271	0.414 (60) 0.828 (120)	0.4999 0.4999	0.546	0.514	0.442
8	325, 297, 322, 294 326, 298, 323, 295 327, 299, 324, 296	0.414 (60)	0.1	0.336	0.339	0.342

* thin specimen, specimen thickness = 0.508 cm.

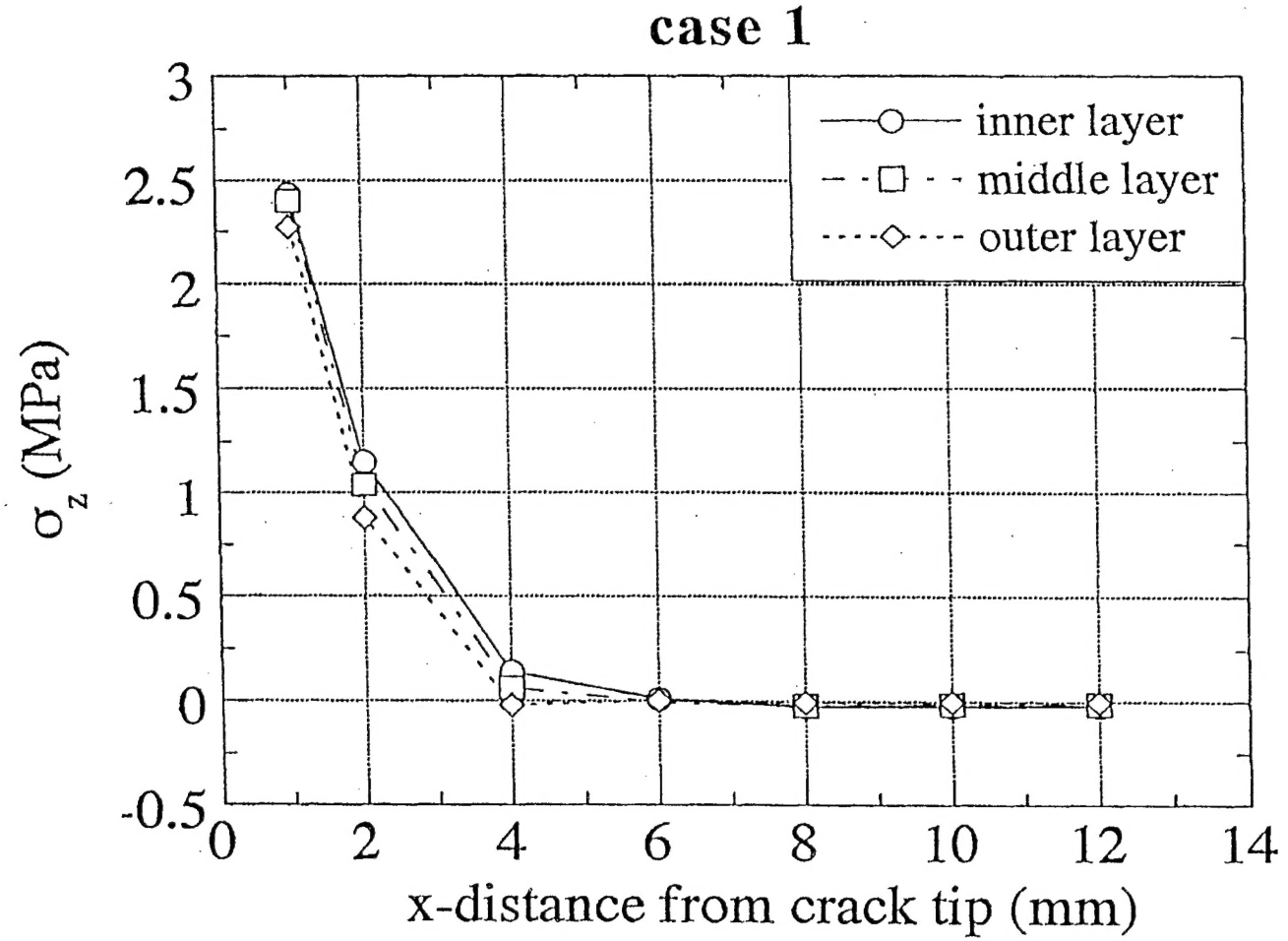
Stress Distributions in the Horizontal Direction



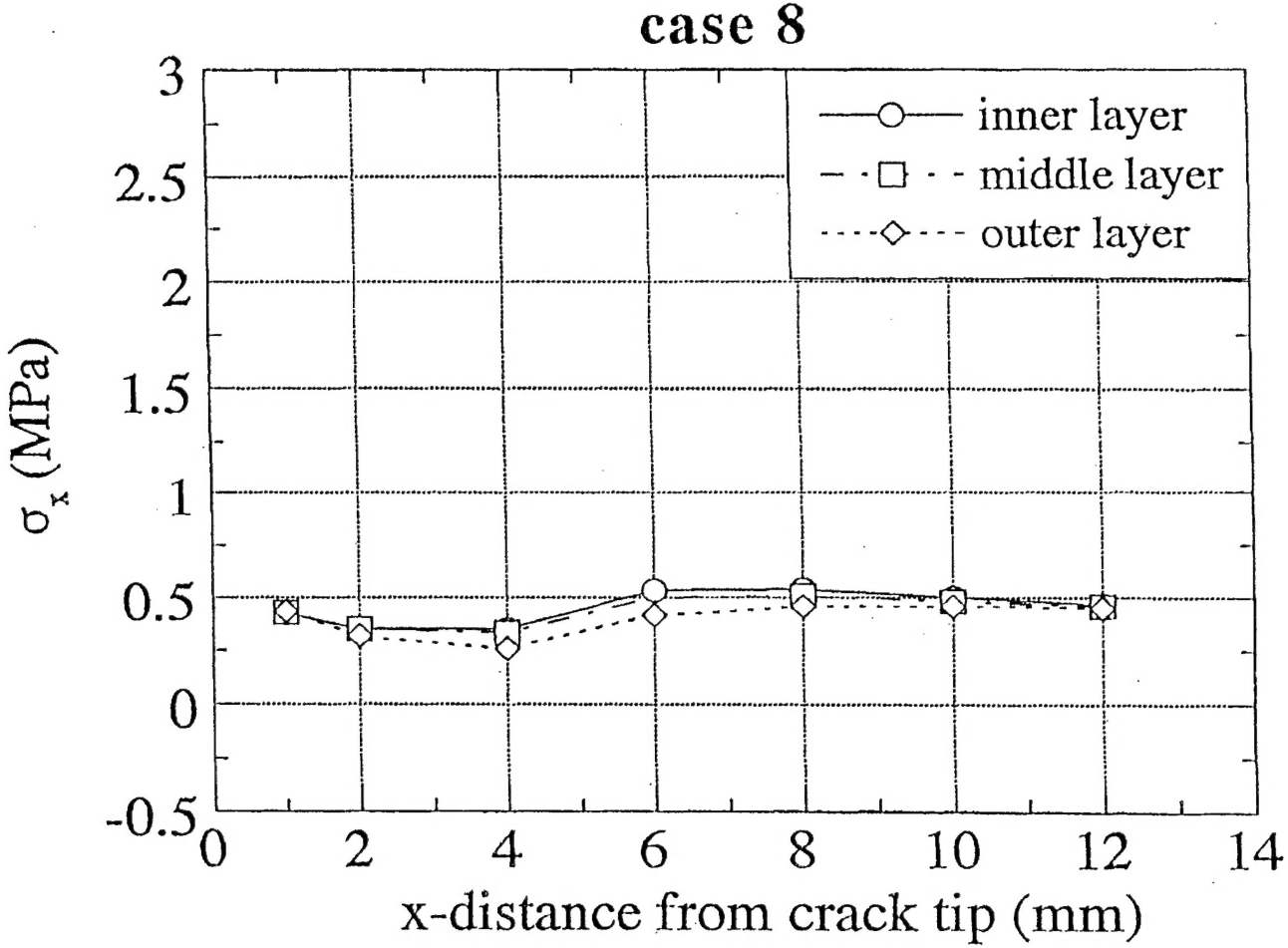
Stress Distributions in the Vertical Direction



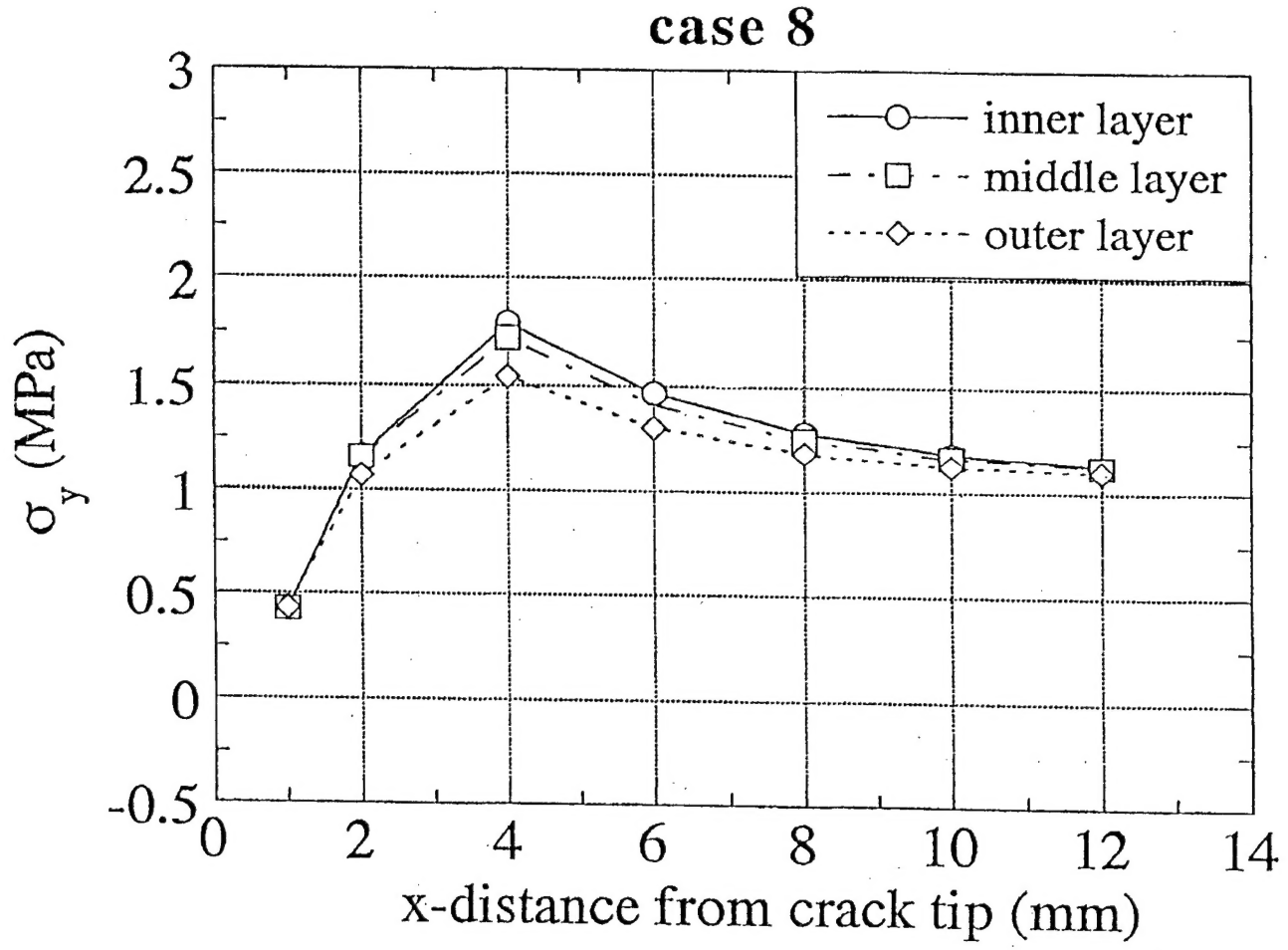
Stress Distributions in the Thickness Direction



Stress Distributions in the Horizontal Direction



Stress Distributions in the Vertical Direction



Stress Distributions in the Thickness Direction